I. Calibration for the **BCBM** Current Transformer:

1. This current transformer is used for all ion species. Devices for controlling this transformer generally can be found at the generic current transformer pet page which is located at *Ags/Instrumentation/Current_xfmrs/current_Xfmr*. Also make sure that pet is displaying pages for the correct, active user. The pound signs in the column after the device name should be changing colors if it is set to the correct user. If not, go to the Page menu, select 'Set PPM User' and choose another user.
2. The calibration pulse can be enabled via the pet software program at the page shown below with a path of *Controllers/Booster/Instrumentation/Ltb*. On the bottom of the picture find the BTG BCBM_ CAL.RT. In column C1, change the value from 'OFF' to 'ON' to turn the calibration pulse on. The calibration pulse can also be turned on from the generic current transformer pet page. The same device of BTG.BCBM_CAL.RT is located on this page under the Booster Circ XF subheading and it operates as described above.

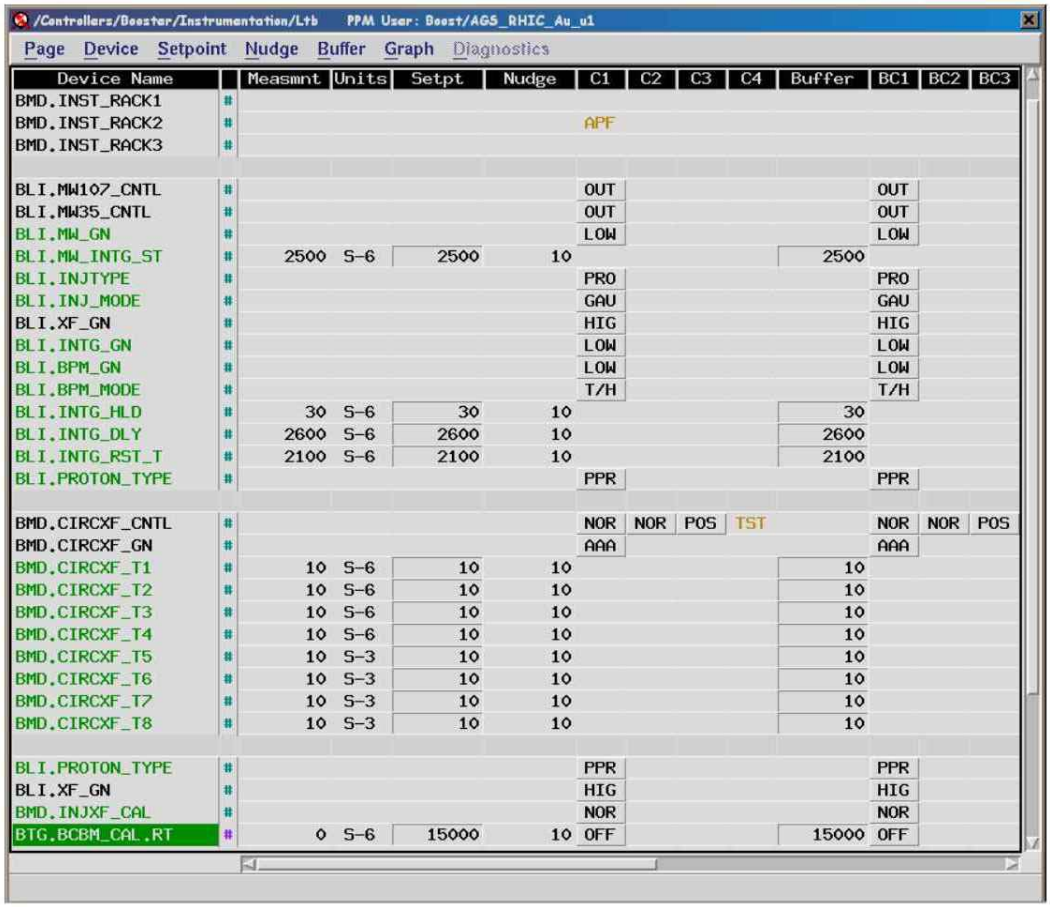


Figure 1 – pet Page for Calibration Pulse Control

3. Check the value of the calibration pulse current. This is determined by the settings for BLI.PROTON_TYPE and BLI.XF_GN. With the Proton Type set to PRO, the calibration pulse is

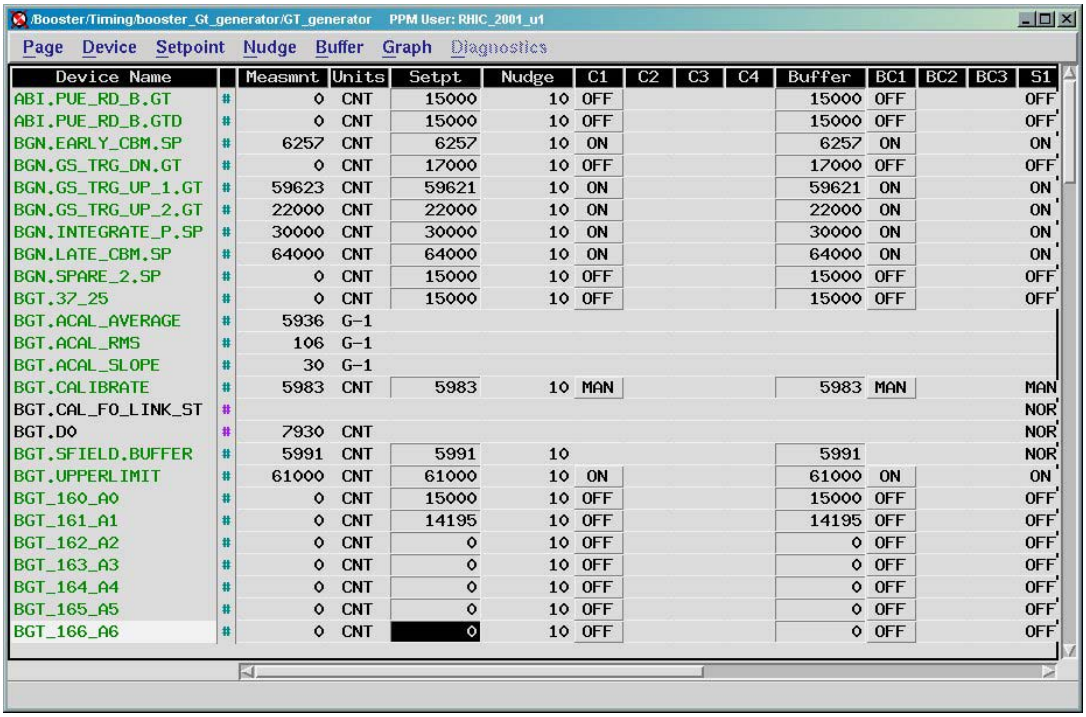
400mA (the setting for XF_GN doesn't matter). For the setting PPR-LOW, the calibration pulse is 5mA and for PPR-HIG, the calibration pulse is 500uA. For heavy ions (Gold, Iron, Silicon, Titanium, Carbon) the setting is usually PPR-HIG, for polarized protons the setting is usually PPR-LOW, and for HEP the setting is PRO-X.

Note: The settings for the given ion species may be changed by MCR or others based on intensity. The settings given above are only a guide and not necessarily fixed to those settings.

Note: On the generic pet page, these devices are located under the Booster Inj XF subheading as the devices control gain for both injection and circulating transformers.

4. Using the rack-mounted scope in Bldg. 911B, Room 222 (over the Main Control Room), display the received pulse of either RK73I05 (the signal direct from the transformer by first connecting it through the buffer amp at RK73A-E08) or at one of the BCBM test points on the electronics modules The scope can be triggered by one of the two signals: either Booster Early at RK73J07 or Booster Late at RK73J08. It is recommended to use Booster Early as the trigger.
5. It will be necessary to move the calibration pulse onto the Booster Early trigger using pet. The path for the necessary device is *Booster/Timing/booster_GT_generator/GT_generator* and the page can be seen in Figure 2. An alternate page is the generic current transformer pet page. The device that needs to be changed to move the calibration pulse is BGN.EARLY_CBM.SP (if using Booster Early as the trigger) or BGN.LATE_CBM.SP (if using Booster Late as the trigger). The value in the Setpt column should be decreased (the delay time made smaller) so that the calibration pulse is sampled at the Booster Early (or Late) trigger. (The scope should be triggering at the center of the calibration pulse.) Make a note of what the original value is as the device will need to have this value returned at the end of the calibration.

   The Early trigger may hit a lower limit if it needs to move too far. This limit is controlled by a device at: *Booster/Timing/booster_GT_generator/BGT.SFIELD.BUFFER*. Adjust this value lower slowly until you can trigger the calibration pulse on the Early trigger. There still may not be enough room to lower SFIELD as there is another device that controls that minimum. That device is: *Booster/Timing/booster_GT_generator/BGT.CALIBRATE*. Lower this until the calibration pulse can be moved to the Early trigger. Remember to put all the values back where they started.
6. Use the equation # ions = I / qnf {where I is the calibration pulse current that was checked in step 3, q is 1.6×10^{-19}, n is the charge value of the ion (1 for protons, 32 for gold, 5 for silicon, 10 for iron, 20 for NSRL iron, 18 for NSRL titanium, and 6 or 5 for NSRL carbon), and f is the revolution frequency at injection (841kHz for protons, 68.3kHz for gold, 103.434kHz for silicon, 103.469kHz for iron, 113.72kHz for NSRL iron, 119.37kHz for NSRL titanium, 158.63kHz for NSRL carbon-6, and 169.043kHz for NSRL carbon-5)} to calculate the expected number of ions for the given calibration pulse current.



Device Name		Measmnt	Units	Setpt	Nudge	C1	C2	C3	C4	Buffer	BC1	BC2	BC3	S1
ABI.PUE_RD_B.GT	#	0	CNT	15000	10	OFF				15000	OFF			OFF
ABI.PUE_RD_B.GTD	#	0	CNT	15000	10	OFF				15000	OFF			OFF
BGN.EARLY_CBM.SP	#	6257	CNT	6257	10	ON				6257	ON			ON
BGN.GS_TRG_DN.GT	#	0	CNT	17000	10	OFF				17000	OFF			OFF
BGN.GS_TRG_UP_1.GT	#	59623	CNT	59621	10	ON				59621	ON			ON
BGN.GS_TRG_UP_2.GT	#	22000	CNT	22000	10	ON				22000	ON			ON
BGN.INTEGRATE_P.SP	#	30000	CNT	30000	10	ON				30000	ON			ON
BGN.LATE_CBM.SP	#	64000	CNT	64000	10	ON				64000	ON			ON
BGN.SPARE_2.SP	#	0	CNT	15000	10	OFF				15000	OFF			OFF
BGT.37_25	#	0	CNT	15000	10	OFF				15000	OFF			OFF
BGT.ACAL_AVERAGE	#	5936	G-1											
BGT.ACAL_RMS	#	106	G-1											
BGT.ACAL_SLOPE	#	30	G-1											
BGT.CALIBRATE	#	5983	CNT	5983	10	MAN				5983	MAN			MAN
BGT.CAL_FO_LINK_ST	#													NOR
BGT.D0	#	7930	CNT											NOR
BGT.SFIELD.BUFFER	#	5991	CNT	5991	10					5991				NOR
BGT.UPPERLIMIT	#	61000	CNT	61000	10	ON				61000	ON			ON
BGT_160_A0	#	0	CNT	15000	10	OFF				15000	OFF			OFF
BGT_161_A1	#	0	CNT	14195	10	OFF				14195	OFF			OFF
BGT_162_A2	#	0	CNT	0	10	OFF				0	OFF			OFF
BGT_163_A3	#	0	CNT	0	10	OFF				0	OFF			OFF
BGT_164_A4	#	0	CNT	0	10	OFF				0	OFF			OFF
BGT_165_A5	#	0	CNT	0	10	OFF				0	OFF			OFF
BGT_166_A6	#	0	CNT	0	10	OFF				0	OFF			OFF

Figure 2 – pet Page for Trigger Timing

Example:

(a) Gold beam is in the machine with SpreadSheet calibration pulse devices set to PPR-HIG $\Rightarrow$ I=500uA, n for gold is 32, and f for gold is 68.3kHz.

(b) Using the given equation, calculate the # of ions: $\frac{500\mu A}{(1.6x10^{-19})(32)(68.3kHz)} = 1.43x10^{9}$

(c) Pay attention to units – there is a mixture of uA, A, kHz, Hz, etc!

7. Make sure the scaler readback at the upper right is connected to the Booster Early V/F output at connector RK73AB07. The value displayed must be the value of the calibration pulse calculated in step 6. The decimal point for Heavy Ions (Gold) is read as 10^9 so 1.430 counts on the scalar would be read as $1.43x10^9$ ions. The decimal point for HEP (protons) is 10^{13}, the decimal point for Polarized Protons is 10^{11}, the decimal point for Iron and Silicon is 10^{10}, and the decimal point for NSRL operations with iron, titanium, and carbon should be set to 10^9 whenever possible.

8. If the number on the scalar reading does not match the calculated value in step 6, then the gain value should be changed on the generic current transformer pet page using the device BIX.XF_BCBM.GAIN. A gain setting of 0 corresponds to x0 gain; a setting of 255 corresponds to x10 gain.

Note: Depending on the mode of operation, the Booster scalar reading may consist of a number of cycles, in which a dummy cycle also exists. Therefore, you may need to multiply the expected value of the calibration pulse by the number of cycles (including the dummy cycle) or the signal will be calibrated wrong. For example, in gold operation if there are 5 Booster cycles plus 1 dummy cycle,

and the expected number of ions according to the calibration pulse is $1.43x10^9$ ions, then the scalars should be reading a total of $1.43x10^9$ ions x 6 cycles = $8.58x10^9$ ions.

9. Once the scalar value is correct, be sure to move the device BGN.EARLY_CBM.SP (or BGN.LATE_CBM.SP if using Booster Late as a trigger and SFIELD.BUFFER and CALIBRATE if they were used as well) back to its original setpoint.